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(54) **DROP-ON-DEMAND MULTI-TONE PRINTING**

DRUCKEN MIT GESTEUERTER TROPFENERZEUGUNG MIT MEHREREN TONWERTEN

IMPRESSION MULTI-TEINTES PAR JET D'ENCRE GOUTTE A LA DEMANDE

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## Description

[0001] This invention relates to drop-on-demand multi-tone printing.

[0002] In particular, a first aspect of the present invention relates to a method of operating a drop-on-demand multi-tone printing apparatus having a series of channels arranged to receive ink from a source, each channel having a respective ink outlet (usually, an appropriately shaped and dimensioned nozzle), each adjacent pair of the channels being separated by a respective dividing wall, and each dividing wall being movable in response to a pulsed electrical signals (for example using the piezo-electric effect) to apply pressure pulses to the ink in the respective pair of the channels, whereby ink can be ejected from the outlets and deposited onto a recording medium.

[0003] A problem with operating such an apparatus is that the signal applied to each dividing wall affects both of the channels to either side of that dividing wall. Patent document WO-A-96/10488 describes ways of dealing with this problem.

[0004] In one example described in WO-A-96/10488, printing of a line of pixels is divided into three cycles. In the first cycle, the dividing walls to either side of channels numbered, for example, 1, 4, 7, ... are driven (if ink is to be ejected from them) with a pulsed signal. In the second cycle, the dividing walls to either side of channels numbered 2, 5, 8, ... are driven (if ink is to be ejected from them) with the pulsed signal. In the third cycle, the dividing walls to either side of channels numbered 3, 6, 9, ... are driven (if ink is to be ejected from them) with the pulsed signal. Thus, the pressure pulses developed in the channels which are not included in the current cycle are no greater than ½ of those in the channels which are intended to eject ink. The printing apparatus is arranged so that such ½ magnitude pulses do not cause ink ejection.

[0005] In another example described in WO-A-96/10488, printing of a line of pixels is divided into two cycles. In the first cycle, the dividing walls to either side of channels numbered 1, 5, 9, ..., for example, are driven (if ink is to be ejected from them) with a first pulsed signal, and the dividing walls to either side of channels 3, 7, 11, ... are driven (if ink is to be ejected from them) with a second pulsed signal which is $\pi$ radians out-of-phase with the first pulsed signal. If the dividing walls to either side of the odd-numbered channels are all driven, then the resultant pressure pulses applied to the even-numbered channels are zero. If the dividing walls to either side of only some of the odd-numbered channels are driven, then the resultant pressure pulses applied to the even-numbered channels can be no more than ½ of the magnitude of those applied to the intended channels. Again, the printing apparatus is arranged so that such ½ magnitude pulses do not cause ink ejection. Conversely, in the second cycle, the dividing walls to either side of channels numbered 2, 6, 10, ..., for example, are driven (if ink is to be ejected from them) with the first pulsed signal, and the dividing walls to either side of channels 4, 8, 12, ... are driven (if ink is to be ejected from them) with the second pulsed signal which is $\pi$ radians out-of -phase with the first pulsed signal.

[0006] A problem with the driving schemes described above is that the requirement for $^2/_3$ or ½ of the channels not to be printing at any time means that the speed of printing is not as high as might be desired.

[0007] A first aspect of the present invention provides a method of operating a drop-on-demand multi-tone printing apparatus having a series of channels arranged to receive ink from a source, each channel having a respective ink outlet, each pair of adjacent channels being separated by a respective dividing wall, and each dividing wall being movable in response to a respective pulsed electrical signal applied thereto, hereafter called a "wall signal", to apply pressure pulses to the ink in the respective pair of the channels, whereby ink can be ejected from the outlets and deposited onto a recording medium, the method comprising the steps of:

developing for each channel a respective pulsed electrical signal, hereafter called a "channel signal", for application to the dividing walls defining the channel in dependence upon whether ink is to be ejected from that channel, the channel signals for pairs of adjacent channels temporally overlapping each other and not being in phase with each other; and

applying to each dividing wall as said wall signal a combination of the respective channel signals developed for the said pair of channels separated thereby, the wall signals respectively applied to the walls bounding a channel together causing droplet ejection when the channel signal for that channel so requires.

[0008] It might be expected that with such a method of operation, unwanted ink ejection will occur. However, as will be apparent from the following description, on the whole, the method enables no more than ½ size pulses to be applied to channels which are not intended to eject ink. When a particular channel is intended to eject, and one of its adjacent channels is also, but the other adjacent channel is not, then the middle channel may be subjected to pulses which are slightly greater than normal, slight distorted and/or slightly phase-shifted compared with normal, but these effects can be arranged so that they are not significant. The method of this aspect of the invention enables ink to be ejected, when necessary, from all of the outlets at the same time, and thus the printing speed can be high.

[0009] Preferably, the channels are arranged in groups each containing a number X ($X \geq 3$, for example four) of the channels, the signals developed for adjacent pairs of the channels being generally $2\pi n/X$ radians out of phase with

each other; where n is an integer not equal to X. Thus, there is a substantially constant phase shift between one channel and the next. Preferably n and X have no common factors.

[0010] Preferably, for each dividing wall, the applying step comprises the steps of: applying the signal developed for the channel to one side of that dividing wall to an electrode on that side of the dividing wall; and applying the signal developed for the channel to the other side of that dividing wall to an electrode on that other side of the dividing wall.

[0011] Preferably, lines of pixels of the ink are deposited onto the recording medium in respective cycles; and, in each cycle, those of the channels which are to eject ink in that cycle begin ejection at the beginning of the cycle and continue ejection until part-way through, or the end of, the cycle. The effect of this is that, if there is a slight phase-shift when, as described above, a particular channel is ejecting, and one of its adjacent channels is also, but the other adjacent channel is not, two such phase shifts in opposite directions will not occur for a single channel in succession.

[0012] The signals developed for each channel may be generally square-wave signals or generally sinusoidal.

[0013] A second aspect of the present invention provides a drop-on-demand multi-tone printing apparatus, comprising:

> a series of channels arranged to receive ink from a source, each channel having a respective ink outlet, each pair of adjacent channels being separated by a respective dividing wall, and each dividing wall being movable in response to a respective pulsed electrical signal applied thereto, hereafter called a "wall signal", to apply pressure pulses to the ink in the respective pair of the channels, whereby ink can be ejected from the outlets and deposited onto a recording medium;
>
> means for developing for each channel a respective pulsed electrical signal, hereafter called a "channel signal", for application to the dividing walls defining the channel in dependence upon whether ink is to be ejected from that channel, the channel signals for pairs of adjacent channels temporally overlapping each other and not being in phase with each other; and
>
> means for applying to each dividing wall as said wall signal a combination of the respective channel signals developed for the said pair of channels separated thereby, the wall signals respectively applied to the walls bounding a channel together causing droplet ejection when the channel signal for that channel so requires.

[0014] The printing apparatus may be provided with various features so as to perform the preferred steps of the method described above.

[0015] A specific embodiment of the present invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

| | |
|---|---|
| Figure 1 | is a schematic drawing of part of a printing apparatus; |
| Figure 2 | illustrates various sinusoidal signal waveforms produced in the apparatus of figure 1; |
| Figure 3 | illustrates various signal waveforms produced in the apparatus when depositing the maximum amount of ink; |
| Figure 4 | illustrates various signal waveforms produced in the apparatus during an example of multi-tone printing; |
| Figures 5 and 6 | are phase diagrams used to explain the operation of the apparatus; and |
| Figure 7 | is similar to figure 4, but illustrates a case where square-wave waveforms are used. |

[0016] Referring to figure 1, a drop-on-demand multi-tone printing apparatus comprises a print head 10, part of which is shown in the drawing, which is fed from an ink reservoir 12. The print head 10 has a series of parallel walls 14, which define between them a series of parallel channels 16. As viewed in the figure 1, the left end of each channel 16 communicates with the ink reservoir 12, and a nozzle 18 is provided at the right end of each channel 16. Each wall 14 is formed of a piezo-electric material oriented so that when an electric field of one polarity is applied to it, the wall 14 distorts so as to reduce the volume of the channel to one side of it and to increase the volume of the channel on the other side of it. Conversely, when an electric field of the opposite polarity is applied, the wall 14 distorts so as to increase the volume of the channel on the one side and to decrease the volume of the channel on the other side. The changes in volume produce pressure changes in the ink, so by applying streams of pulsiform signals to the walls 14, pressure pulses can be generated in the channels, causing streams of droplets 20 of ink to be ejected from the nozzles 18 towards a recording medium 22 such as a sheet of paper. By varying the lengths of the stream of pulses, the number of droplets which are ejected can be varied, so as to perform multi-tone printing. Once a line of pixels of ink has been deposited on the paper 22, the print head 10 and paper 22 are moved relative to each other in the direction perpendicular to the plane of the drawing of figure 1, and a further line of pixels of ink can then be deposited. Alternatively, this relative movement may be continuous. The arrangement as described so far with reference to figure 1 is known, for example from patent documents WO-A-95/25011 and WO-A-96/10488.

[0017] As shown also in figure 1, a sine wave generator 24 is provided, which produces a signal G(0). This is fed to

a series of three quarter-wave delay circuits 26 to produce signals G(1), G(2) and G(3) which phase lag the signal G (0) by $\pi/2$, $\pi$ and $3\pi/2$ radians, respectively, as shown in figure 2.

[0018] In figure 1, only four of the channels 16 are shown, and the channels have respective data inputs receiving binary signals D(N), D(N+1), D(N+2) and D(N+3). (For completeness, two other data inputs receiving binary signals D(N-1) and D(N+4) are also shown.) The signal D(N) is used to control a switch 28 to produce a signal C(N) which is equal to the signal D(N) or is grounded, in dependence upon the logical state of the signal D(N). Similarly, the signals G(1), G(2), G(3) are switched by respective switches 28 under control of the signals D(N+1), D(N+2), D(N+3) to produce signals C(N+1), C(N+2) and C(N+3), respectively. This connection arrangement is repeated for every four input signals, e.g D(N+4) to D(N+7), D(N+8) to D(N+11), and so on. Each signal C(i) is applied to a pair of electrodes 30 on the piezo-electric walls 14 to either side of its respective channel 16(i). The potential difference W(i-1)(i) across each wall 14 between an adjacent pair of the channels 16(i-1), 16(i) is given by

$$W(i-1)(i) = C(i) - C(i-1) \qquad \text{equation 1.}$$

[0019] The change in volume of a channel 16(i) caused by the applied signals is denoted in the drawings as V(i) and is proportional to the net displacement of the walls bounding the channel. The displacement of each wall is generally proportional to the potential difference across it. Hence, if the constant of proportionality is assumed to be unity,

$$V(i) = W(i)(i+1) - W(i-1)(i) \qquad \text{equation 2}$$

[0020] Figure 3 of the drawings show the above-mentioned signals plotted with a time abscissa in the case where all of the input signals D(i) have a logic level of 1 so as to print a line of maximum density on the paper 22. As can be seen, the change of volume waveforms V(i) are regular sinusoidal waves, and thus even injection of the droplets 20 is produced.

[0021] Figure 4 illustrates the case where, in a cycle between time T1 and time T2, the channels 16(N-1) and 16 (N+3) are intended to eject droplets 20 for the complete cycle T1 to T2, the channels 16(N+1) and 16(N+4) are intended to eject droplets 20 for the first three-quarters of the cycle T1 to Tc, the channel 16(N) is intended to eject droplets 20 for the first half of the cycle T1 to Tb, and the channel 16(N+2) is intended to eject droplets 20 for the first quarter of the cycle T1 to Ta. In Figure 4, the actual volume change waveforms V(N) to V(N+3) are shown in bold, and the waveforms of Figure 3, where different, are overlaid as feint traces so that a comparison can be easily made.

[0022] As can be seen, the volume changes V(N) in the channel 16(N) are, during the first half of the cycle T1 to Tb, similar to those shown in figure 3 and cause a stream of droplets 20 to be ejected. In the third quarter of the cycle Tb to Tc, there are no volume changes in the channel 16(N), and so no droplets 20 are ejected. In the fourth quarter of the cycle Tc to T2, the volume changes in the channel 16(N) have a 50% magnitude, and are insufficient to cause any droplets 20 to be ejected.

[0023] The volume changes V(N+1) during the second quarter of the cycle Ta to Tb in the channel 16(N+1), and the volume changes V(N+3) during the second and third quarters of the cycle Ta to Tc in the channel 16(N+3) will now be discussed.

[0024] From equations (1) and (2) above, it follows (assuming constants of proportionality of unity) that

$$V(N+1) = C(N+2) - (2 \times C(N+1)) + C(N) \qquad \text{equation 3.}$$

[0025] Referring to figure 5, during the period T1 to Ta, C(N), C(N+1) and C(N+2) are of equal amplitude, say unity, and mutually lagging by $\pi/2$ radians. Therefore, V(N+1) has an amplitude of 2 which is $\pi$ radians out of phase from C (N+1). During the period Ta to Tb, the amplitude of C(N+2) has become zero, and therefore the amplitude of V(N+1) increases to $2\times(5/4)^{1/2}$, that is by a factor of 1.118 compared with the previous amplitude of V(N+1), and its phase retards by $\tan^{-1} ½$, that is 26.6°, compared with its phase during the period T1 to Ta. During the period Ta to Tb, the amplitude of C(N) has also become zero, and so the amplitude and phase of V(N+1) revert to the same as during the period T1 to Ta. During the period Tc to T2, the amplitude of C(N+1) has also become zero, and therefore V(N+1) becomes zero.

[0026] Referring to figure 6, during the period T1 to Ta, C(N+2), C(N+3) and C(N+4) are of equal amplitude, say unity, and mutually lagging by $\pi/2$ radians. Therefore, V(N+3) has an amplitude of 2 which is $\pi$ radians out of phase from C(N+3). During the period Ta to Tc, the amplitude of C(N+2) has become zero, and therefore the amplitude of V (N+3) increases to $2\times(5/4)^{1/2}$, that is by a factor of 1.118 compared with the previous amplitude of V(N+3), and its phase advances by $\tan^{-1} ½$, that is 26.6°, compared with its phase during the period T1 to Ta. During the period Tc to

T2, the amplitude of C(N+4) has also become zero, and so the amplitude and phase of V(N+3) revert to the same as during the period T1 to Ta.

[0027] It will be appreciated that many modifications and developments may be made to the embodiment of the invention as described above.

[0028] For example, waveforms other than sinusoidal waveforms may be used, for example square waveforms, as shown in figure 7, in which the inputs on line D are the same as in figure 4. Points of note in figure 7 are the volume changes V(N+1) during the second quarter of the cycle in the channel 16(N+1), and the volume changes V(N+3) during the second and third quarters of the cycle in the channel 16(N+3). Here, the waveforms are no longer square, but have portions removed from some parts of the waveform and added on elsewhere. It will be appreciated, however, the apparatus can be constructed so that these irregular waves are sufficient to cause droplet ejection.

[0029] In the embodiments described above, the channels 16 are grouped in fours, and signals are applied which are phase-shifted by $\pi/2$ radians. Alternatively, the channels 16 may be grouped in larger groups, for example in groups of five or six, in which case the signals which are applied may be phase-shifted by $2\pi/5$ or $\pi/3$ radians. As a generality, the phase difference between the signals for adjacent channels is $2\pi n/X$ where n is an integer. So far, the description has assumed that n=1, but for other values of n different phase relationships may be obtained.

[0030] The following table of examples illustrates the principle:

| n | X | Relative channel signal phase as fraction of $2\pi$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | 5 | 0 | 1/5 | 2/5 | 3/5 | 4/5 | 0 | | |
| 2 | 5 | 0 | 2/5 | 4/5 | 1/5 | 3/5 | 0 | | |
| 1 | 6 | 0 | 1/6 | 2/6 | 3/6 | 4/6 | 5/6 | 0 | |
| 2 | 6 | 0 | 2/6 | 4/6 | 0 | 2/6 | 4/6 | 0 | |
| 1 | 7 | 0 | 1/7 | 2/7 | 3/7 | 4/7 | 5/7 | 6/7 | 0 |
| 2 | 7 | 0 | 2/7 | 4/7 | 6/7 | 1/7 | 3/7 | 5/7 | 0 |
| 3 | 7 | 0 | 3/7 | 6/7 | 2/7 | 5/7 | 1/7 | 4/7 | 0 |
| 4 | 7 | 0 | 4/7 | 1/7 | 5/7 | 2/7 | 6/7 | 3/7 | 0 |

[0031] As can be seen for n=2, X=6 the effect is the same as for n=1, X=3. In other words if n and X have a common factor the effect is the same as if that factor is cancelled from n and X. By choosing n $\neq$ 1, with no common factor, the phase relationship between adjacent channels of a group can be changed without affecting the grouping of the channels as a whole. In practice n is chosen to be less than X. For n greater than X, patterns for n<X are merely repeated.

[0032] Temperature compensation techniques may be employed, for example as described in patent applications GB 9605547.0 and PCT/GB97/00733.

## Claims

1. A method of operating a drop-on-demand multi-tone printing apparatus having a series of channels (16) arranged to receive ink from a source (12), each channel having a respective ink outlet (18), each pair of adjacent channels (16(i), 16(i-1)) being separated by a respective dividing wall (14), and each dividing wall being movable in response to a respective pulsed electrical signal (W(i-1)(i)) applied thereto, hereafter called a "wall signal", to apply pressure pulses to the ink in the respective pair of the channels (16(i), 16(i-1)), whereby ink can be ejected from the outlets (18) and deposited onto a recording medium (22), the method comprising the steps of:

   developing for each channel (16(i)) a respective pulsed electrical signal (C(i)), hereafter called a "channel signal", for application to the dividing walls (14) defining the channel (16(i)) in dependence upon whether ink is to be ejected from that channel, the channel signals (C(i), C(i-1)) for pairs of adjacent channels (16(i), 16(i-1)) temporally overlapping each other and not being in phase with each other; and

   applying to each dividing wall (14) as said wall signal (W(i-1)(i)) a combination of the respective channel signals (C(i), C(i-1)) developed for the said pair of channels (16(i), 16(i-1)) separated thereby, the wall signals (W(i)(i+1), W(i-1)(i)) respectively applied to the walls bounding a channel together causing droplet ejection when the channel signal (C(i)) for that channel (16(i)) so requires.

2. A method as claimed in claim 1, wherein the channels (16) are arranged in groups each containing a number X of the channels, where $X \geq 3$, the channel signals (C(i), C(i-1)) developed for pairs of adjacent channels (16(i), 16 (i-1)) being generally $2\pi n/X$ radians out of phase with each other, where n is an integer not equal to x.

3. A method as claimed in claim 2, wherein the number X is four.

4. A method as claimed in any preceding claim, wherein, for each dividing wall (14), the wall signal comprises the combination of:

the channel signal (C(i)) developed for the channel to one side of that dividing wall (14) and applied to an electrode (30) on that side of the dividing wall; and
the channel signal (C(i-1)) developed for the channel to the other side of that dividing wall (14) and applied to an electrode (30) on that other side of the dividing

5. A method as claimed in any preceding claim, wherein:

lines of pixels of the ink are deposited onto the recording medium in respective cycles; and
in each cycle, those of the channels which are to eject ink in that cycle begin ejection at the beginning of the cycle and continue ejection until part-way through, or the end of, the cycle.

6. A method as claimed in any preceding claim, wherein the channel signals developed for each channel are generally square-wave signals.

7. A method as claimed in any of claims 1 to 5, wherein the channel signals developed for each channel are generally sinusoidal.

8. A drop-on-demand multi-tone printing apparatus, comprising:

a series of channels (16) arranged to receive ink from a source (12), each channel having a respective ink outlet (18), each pair of adjacent channels (16(i), 16(i-1)) being separated by a respective dividing wall (14), and each dividing wall being movable in response to a respective pulsed electrical signal (W(i-1)(i)) applied thereto, hereafter called a "wall signal", to apply pressure pulses to the ink in the respective pair of the channels (16(i), 16(i-1)), whereby ink can be ejected from the outlets (18) and deposited onto a recording medium (22);
means (24, 26, 28) for developing for each channel (16(i)) a respective pulsed electrical signal (C(i)), hereafter called a "channel signal", for application to the dividing walls (14) defining the channel (16(i)) in dependence upon whether ink is to be ejected from that channel, the channel signals (C(i), C(i-1)) for pairs of adjacent channels (16(i), 16(i-1)) temporally overlapping each other and not being in phase with each other; and
means (24, 26, 28) for applying to each dividing wall (14) as said wall signal (W(i-1)(i)) a combination of the respective channel signals (C(i), C(i-1)) developed for the said pair of channels (16(i), 16(i-1)) separated thereby, the wall signals (W(i)(i+1), W(i-1)(i)) respectively applied to the walls bounding a channel together causing droplet ejection when the channel signal (C(i)) for that channel (16(i)) so requires.

9. Apparatus as claimed in claim 8, wherein the channels (16) are arranged in groups each containing a number X of the channels, where $X \geq 3$, the channel signals (C(i), C(i-1)) developed for pairs of adjacent channels (16(i), 16 (i-1)) being generally $2\pi n/X$ radians out of phase with each other, where n is an integer not equal to X.

10. Apparatus as claimed in claim 9, wherein the number X is four.

11. Apparatus as claimed in any of claims 8, 9 or 10 wherein, for each dividing wall, the means for applying the combination of channel signals comprises:

means (24, 26, 28) for applying the channel signal (C(i)) developed for the channel to one side of that dividing wall to an electrode (30) on that side of the dividing wall; and
means (24, 26, 28) for applying the channel signal (C(i-1)) developed for the channel to the other side of that dividing wall to an electrode (30) on that other side of the dividing wall.

12. Apparatus as claimed in any of claims 8 to 11 wherein:

the channel signals are such that in operation lines of pixels of the ink are deposited onto the recording medium in respective cycles; and
in each cycle, those of the channels which are to eject ink in that cycle begin ejection at the beginning of the cycle and continue ejection until part-way through, or the end of, the cycle.

13. Apparatus as claimed in any of claims 8 to 12, wherein the channel signals developed for each channel are generally square-wave signals.

14. Apparatus as claimed in any of claims 8 to 12, wherein the channel signals developed for each channel are generally sinusoidal.

**Patentansprüche**

1. Verfahren zum Betreiben einer Druckvorrichtung mit mehreren Tonwerten und Tropfen auf Anforderung (drop-on-demand) mit einer Serie von Kanälen (16), welche angeordnet sind, um Tinte von einer Quelle (12) zu erhalten, wobei jeder Kanal jeweils einen Tintenauslass (18) aufweist, wobei jedes Paar von benachbarten Kanälen (16(i), 16(i-1)) getrennt ist durch eine jeweilige Trennwand (14), und jede Trennwand ist bewegbar in Reaktion auf ein jeweils gepulstes elektrisches Signal (W(i-1)(i)), welches daran angelegt wird, hiernach als ein "Wandsignal" bezeichnet, um Druckimpulse an die Tinte in dem jeweiligen Paar der Kanäle (16(i), 16(i-1)) anzulegen, wodurch die Tinte von den Auslässen (18) ausgestoßen und auf einem Aufzeichnungsmedium (22) abgelagert werden kann, wobei das Verfahren die Schritte aufweist:

   Entwickeln eines jeweiligen gepulsten elektrischen Signals (C(i)) für jeden Kanal (16(i)), hiernach ein "Kanal-Signal" genannt, zum Anlegen an die Trennwände (14), welche den Kanal (16(i)) definieren, in Abhängigkeit davon, ob eine Tinte von diesem Kanal ausgestoßen werden soll, wobei sich die Kanal-Signale (C(i), C(i-1)) für Paare von benachbarten Kanälen (16(i), 16(i-1)) zeitlich miteinander überlappen und miteinander nicht in Phase sind; und
   Anlegen einer Kombination der jeweiligen Kanal-Signale (C(i), C(i-1)) an jede Trennwand (14) als das Wandsignal (W(i-1)(i)), welche entwickelt wurden für das Paar der Kanäle (16(i), 16(i-1)), welche dadurch getrennt sind, wobei die Wandsignale (W(i)(i+1), W(i-1)(i)), welche jeweils an die Wände welche einen Kanal begrenzen angelegt werden, zusammen das Ausstoßen eines Tröpfchens verursachen, wenn das Kanal-Signal (C(i)) für diesen Kanal (16(i)) dies verlangt.

2. Verfahren nach Anspruch 1, wobei die Kanäle (16) in Gruppen angeordnet sind, welche jeweils eine Anzahl X der Kanäle enthalten, wobei $X \geq 3$, wobei die Kanal-Signale (C(i), C(i-1)), welche entwickelt wurden für Paare von benachbarten Kanälen (16(i), 16(i-1)) im Allgemeinen $2\pi n/X$ Radiant außerhalb der Phase zueinander liegen, wobei n eine ganze Zahl ungleich X ist.

3. Verfahren nach Anspruch 2, wobei die Anzahl X vier ist.

4. Verfahren nach einem der vorhergehenden Ansprüche, wobei für jede Trennwand (14) das Wand-Signal eine Kombination aufweist aus:

   dem Kanal-Signal (C(i)), welches entwickelt wurde für den Kanal auf einer Seite dieser Trennwand (14) und angelegt an eine Elektrode (30) auf dieser Seite der Trennwand; und
   das Kanal-Signal (C(i-1)), welches entwickelt wurde für den Kanal an der anderen Seite dieser Trennwand (14) und angelegt an eine Elektrode (30) auf dieser anderen Seite der Trennwand (14).

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei:

   Zeilen von Pixeln bzw. Bildelementen der Tinte auf dem Aufzeichnungsmedium in jeweiligen Zyklen abgelagert werden; und
   in jedem Zyklus diejenigen der Kanäle, welche Tinte in diesem Zyklus ausstoßen sollen, mit dem Ausstoßen beim Beginn des Zyklus beginnen und mit dem Ausstoßen fortfahren bis zu einem Teilweg durch oder dem Ende des Zyklus.

6. Verfahren nach einem der vorhergehenden Ansprüche, wobei die Kanal-Signale, welche für jeden Kanal entwickelt

wurden, im Allgemeinen rechteckförmige Signale sind.

7. Verfahren nach einem der Ansprüche 1 bis 5, wobei die Kanal-Signale, welche für jeden Kanal entwickelt wurden, im Allgemeinen sinusförmig sind.

8. Druckvorrichtung für mehrere Tonwerte für einen Tropfen auf Anforderung (drop-on-demand) mit:

einer Serie von Kanälen (16) welche angeordnet sind, um Tinte von einer Quelle (12) zu erhalten, wobei jeder Kanal jeweils einen Tintenauslass (18) aufweist, wobei jedes Paar hier von benachbarten Kanälen (16(i), 16 (i-1)) getrennt ist durch eine jeweilige Trennwand (14), und jede Trennwand ist bewegbar in Reaktion auf ein jeweils gepulstes elektrisches Signal (W(i-1)(i)), welches daran angelegt wird, hiernach als ein "Wandsignal" bezeichnet, um Druckimpulse an die Tinte in dem jeweiligen Paar der Kanäle (16(i), 16(i-1)) anzulegen, wodurch die Tinte von den Auslässen (18) ausgestoßen und auf einem Aufzeichnungsmedium (22) abgelagert werden kann;
einer Vorrichtung (24, 26, 28) zum Entwickeln eines jeweils gepulsten elektrischen Signals (C(i)) für jeden Kanal (16(i)), hiernach ein "Kanal-Signal" genannt, zum Anlegen an die Trennwände (14), welche den Kanal (16(i)) definieren, in Abhängigkeit davon, ob eine Tinte von diesem Kanal ausgestoßen werden soll, wobei sich die Kanal-Signale (C(i), C(i-1)) für Paare von benachbarten Kanälen (16(i), 16(i-1)) zeitlich miteinander überlappen und nicht miteinander in Phase sind; und
einer Vorrichtung (24, 26, 28) zum Anlegen einer Kombination der jeweiligen Kanal-Signale (C(i), C(i-1)) als das Wandsignal (W(i-1)(i)) an jede Trennwand (14), welche entwickelt wurden für das Paar der Kanäle (16(i), 16(i-1)), welche dadurch getrennt sind, wobei die Wandsignale (W(i)(i+1), W(i-1)(i)), welche jeweils angelegt werden an die Wände, welche zusammen einen Kanal begrenzen, einen Tröpfchen-Ausstoß verursachen, wenn das Kanal-Signal (C(i)) für diesen Kanal (16(i)) dies so erfordert.

9. Vorrichtung nach Anspruch 8, wobei die Kanäle (16) in Gruppen angeordnet sind, welche jeweils eine Anzahl X der Kanäle enthalten, wobei X ≥3, wobei die Kanal-Signale (C(i), C(i-1)), welche entwickelt wurden für Paare von benachbarten Kanälen (16(i), 16(i-1)) im Allgemeinen $2\pi n/X$ Radiant außerhalb der Phase zueinander liegen, wobei n eine ganze Zahl ungleich X ist.

10. Vorrichtung nach Anspruch 9, wobei die Anzahl X vier ist.

11. Vorrichtung nach einem der Ansprüche 8, 9 oder 10, wobei für jede Trennwand die Vorrichtung zum Anlegen der Kombination der Kanal-Signale aufweist:

eine Vorrichtung (24, 26, 28) zum Anlegen des Kanal-Signals (C(i)), welches entwickelt wurde für den Kanal an einer Seite dieser Trennwand an eine Elektrode (30) auf dieser Seite der Trennwand; und
eine Vorrichtung (24, 26, 28) zum Anlegen des Kanal-Signals (C(i-1)), welches entwickelt wurde für den Kanal an der anderen Seite dieser Trennwand an eine Elektrode (30) auf dieser anderen Seite der Trennwand.

12. Vorrichtung nach einem der Ansprüche 8 bis 11, wobei:

die Kanal-Signale so sind, dass beim Betrieb Zeilen von Pixeln der Tinte auf dem Aufzeichnungsmedium in jeweiligen Zyklen abgelagert werden; und
in jedem Zyklus diejenigen der Kanäle, welche Tinte in diesem Zyklus ausstoßen sollen, mit dem Ausstoßen beim Anfang des Zyklus anfangen und mit dem Ausstoßen fortfahren bis zu einem Teil durch oder dem Ende des Zyklus.

13. Vorrichtung nach einem der Ansprüche 8 bis 12, wobei die Kanal-Signale, welche für jeden Kanal entwickelt wurden, im Allgemeinen rechteckförmige Signale sind.

14. Vorrichtung nach einem der Ansprüche 8 bis 12, wobei die Kanal-Signale, welche für jeden Kanal entwickelt wurden, im Allgemeinen sinusförmig sind.

## Revendications

1. Procédé de commande d'un appareil d'impression à tons multiples à goutte à la demande comprenant une série

de canaux (16) agencés pour recevoir de l'encre venant d'une source (12), chaque canal ayant une sortie d'encre respective (18), deux canaux adjacents quelconques (16(i), 16(i-1)) étant séparés par une paroi de séparation respective (14) et chaque paroi de séparation étant déplaçable en réponse à un signal électrique pulsé respectif (W(i-1)(i)) appliqué à cette paroi, appelé dans ce qui suit "signal de paroi", pour appliquer des impulsions de pression à l'encre dans les deux canaux respectifs (16(i), 16(i-1)) de sorte que de l'encre peut être éjectée aux sorties (18) et déposée sur un support d'enregistrement (22), le procédé comprenant les étapes de :

génération, pour chaque canal (16(i)), d'un signal électrique pulsé respectif (C(i)), appelé dans ce qui suit "signal de canal", pour application aux parois de séparation (14) définissant le canal (16(i)) en fonction de ce que de l'encre doit ou non être éjectée de ce canal, les signaux de canal (C(i), C(i-1)) pour deux canaux adjacents quelconques (16(i), 16(i-1)) se chevauchant temporellement et n'étant pas en phase l'un avec l'autre ; et

application à chaque paroi de séparation (14); comme dit signal de paroi (W(i-1)(i)), d'une combinaison des signaux de canal respectifs (C(i), C(i-1)) engendrés pour les dits deux canaux (16 (i), 16 (i-1)) séparés par cette paroi, les signaux de paroi (W(i)(i+1), W(i-1)(i)) respectivement appliqués aux parois qui délimitent un canal provoquant ensemble une éjection de gouttelette lorsque le signal de canal (C(i)) pour ce canal (16(i)) le demande.

2. Procédé selon la revendication 1, dans lequel les canaux (16) sont agencés en groupes contenant chacun un nombre X de canaux, où X 3, les signaux de canal (C(i), C(i-1)) engendrés pour deux canaux adjacents quelconques (16(i), 16(i-1)) étant sensiblement mutuellement déphasés de $2\pi n/X$ radians, où n est un entier non égal à X,

3. Procédé selon la revendication 2, dans lequel le nombre X est de 4.

4. Procédé selon une quelconque des revendications précédentes, dans lequel, pour chaque paroi de séparation (14), le signal de paroi comprend en combinaison :

le signal de canal (C(i)) engendré pour le canal situé d'un côté de cette paroi de séparation (14) et appliqué à une électrode (30) sur ce côté de la paroi de séparation ; et

le signal de canal (C(i-1)) engendré pour le canal situé de l'autre côté de cette paroi de séparation (14) et appliqué à une électrode (30) sur cet autre côté de la paroi de séparation.

5. Procédé selon une quelconque des revendications précédentes, dans lequel :

des lignes de pixels de l'encre sont déposées sur le support d'enregistrement dans des cycles respectifs ; et dans chaque cycle, ceux des canaux qui doivent éjecter de l'encre dans ce cycle commencent l'éjection au début du cycle et poursuivent l'éjection pendant une partie du cycle ou jusqu'à la fin du cycle.

6. Procédé selon une quelconque des revendications précédentes, dans lequel les signaux de canal engendrés pour chaque canal sont des signaux sensiblement à onde carrée.

7. Procédé selon une quelconque des revendications 1 à 5, dans lequel les signaux de canal engendrés pour chaque canal sont sensiblement sinusoïdaux.

8. Appareil d'impression à tons multiples à goutte à la demande, comprenant :

une série de canaux (16) agencés pour recevoir de l'encre venant d'une source (12), chaque canal ayant une sortie d'encre respective (18), deux canaux adjacents quelconques (16(i), 16(i-1)) étant séparés par une paroi de séparation respective (14) et chaque paroi de séparation étant déplaçable en réponse à un signal électrique pulsé respectif (W(i-1)(i)) appliqué à cette paroi, appelé dans ce qui suit "signal de paroi", pour appliquer des impulsions de pression à l'encre qui se trouve dans les deux canaux respectifs (16(i), 16(i-1)), de sorte que de l'encre peut être éjectée aux sorties (18) et déposée sur un support d'enregistrement (22) ;

des moyens (24, 26, 28) de génération, pour chaque canal (16(i)), d'un signal électrique pulsé respectif (C(i)), appelé dans ce qui suit "signal de canal", pour application aux parois de séparation (14) qui définissent le canal (16)(i)) en fonction de ce que l'encre doit ou non être éjectée de ce canal, les signaux de canal (C(i)), C(i-1)) de deux canaux adjacents quelconques (16(i), 16(i-1)) se chevauchant temporellement et n'étant pas en phase l'un avec l'autre ; et

des moyens (24, 26, 28) pour appliquer à chaque paroi de séparation (14), comme dit signal de paroi (W(i-1)

(i)), une combinaison de signaux de canal respectifs (C(i), C(i-1)) engendrés pour les dits deux canaux (16(i), 16(i-1)) séparés par cette paroi, les signaux de paroi (W(i)(i+1), W(i-1)(i)) respectivement appliqués aux parois qui délimitent un canal provoquant ensemble l'éjection de gouttelettes lorsque le signal de canal (C(i)) pour ce canal (16(i)) le demande.

**9.** Appareil selon la revendication 8, dans lequel les canaux (16) sont agencés en groupes contenant chacun un nombre X de canaux, où X 3, les signaux de canal (C(i), C(i-1)) engendrés pour deux canaux adjacents quelconques (16(i), 16(i-1)) étant sensiblement déphasés de $2\pi n/X$ radians l'un par rapport à l'autre, où n est un entier non égal à X.

**10.** Appareil selon la revendication 9, dans lequel le nombre X est de 4.

**11.** Appareil selon une quelconque des revendications 8, 9 ou 10, dans lequel, pour chaque paroi de séparation, les moyens d'application de la combinaison de signaux de canal comprennent :

des moyens (24, 26, 28) d'application du signal de canal (C(i)), engendré pour le canal situé d'un côté de cette paroi de séparation, à une électrode (30) placé sur ce côté de la paroi de séparation ; et
des moyens (24, 26, 28) d'application du signal de canal (C(i-1)) engendré pour le canal situé de l'autre côté de cette paroi de séparation à une électrode (30) placée sur cet autre côté de la paroi de séparation.

**12.** Appareil selon une quelconque des revendications 8 à 11, dans lequel :

les signaux de canal sont tels que, en fonctionnement, des lignes de pixels de l'encre sont déposées sur le support d'enregistrement dans des cycles respectifs ; et
dans chaque cycle, ceux des canaux qui doivent éjecter de l'encre dans ce cycle commencent l'éjection au début du cycle et continuent l'éjection pendant une partie ou jusqu'à la fin du cycle.

**13.** Appareil selon une quelconque des revendications 8 à 12, dans lequel les signaux de canal engendrés pour chaque signal sont des signaux sensiblement à onde carrée.

**14.** Appareil selon une quelconque des revendications 8 à 12, dans lequel les signaux de canal engendrés pour chaque canal sont sensiblement sinusoïdaux.

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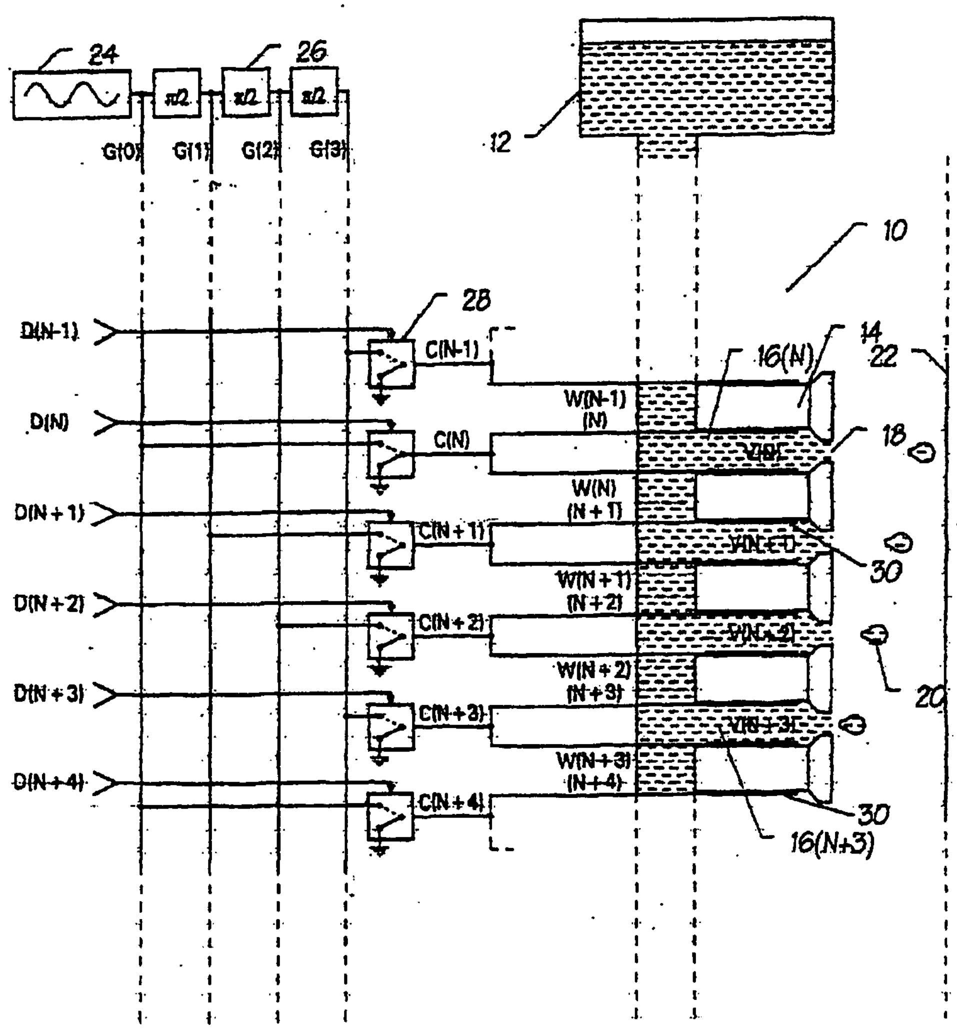



FIG. 1

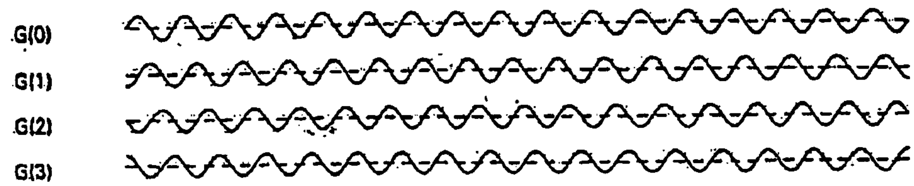



FIG. 2

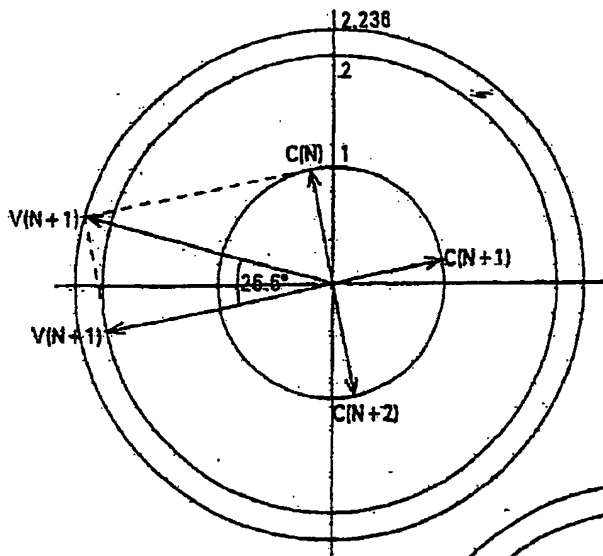



FIG. 5

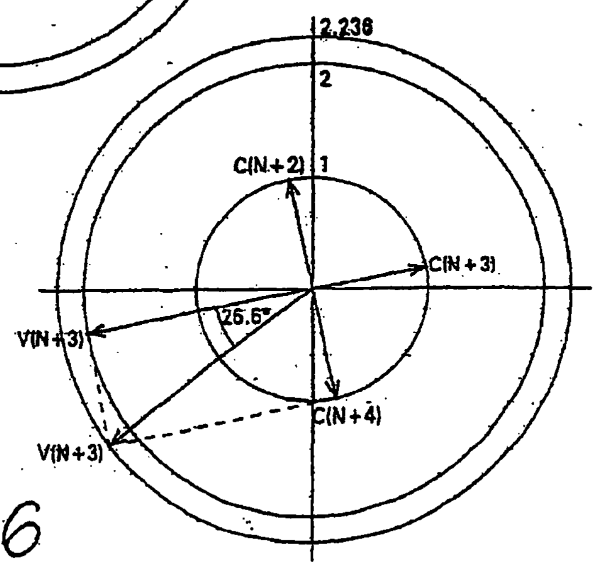
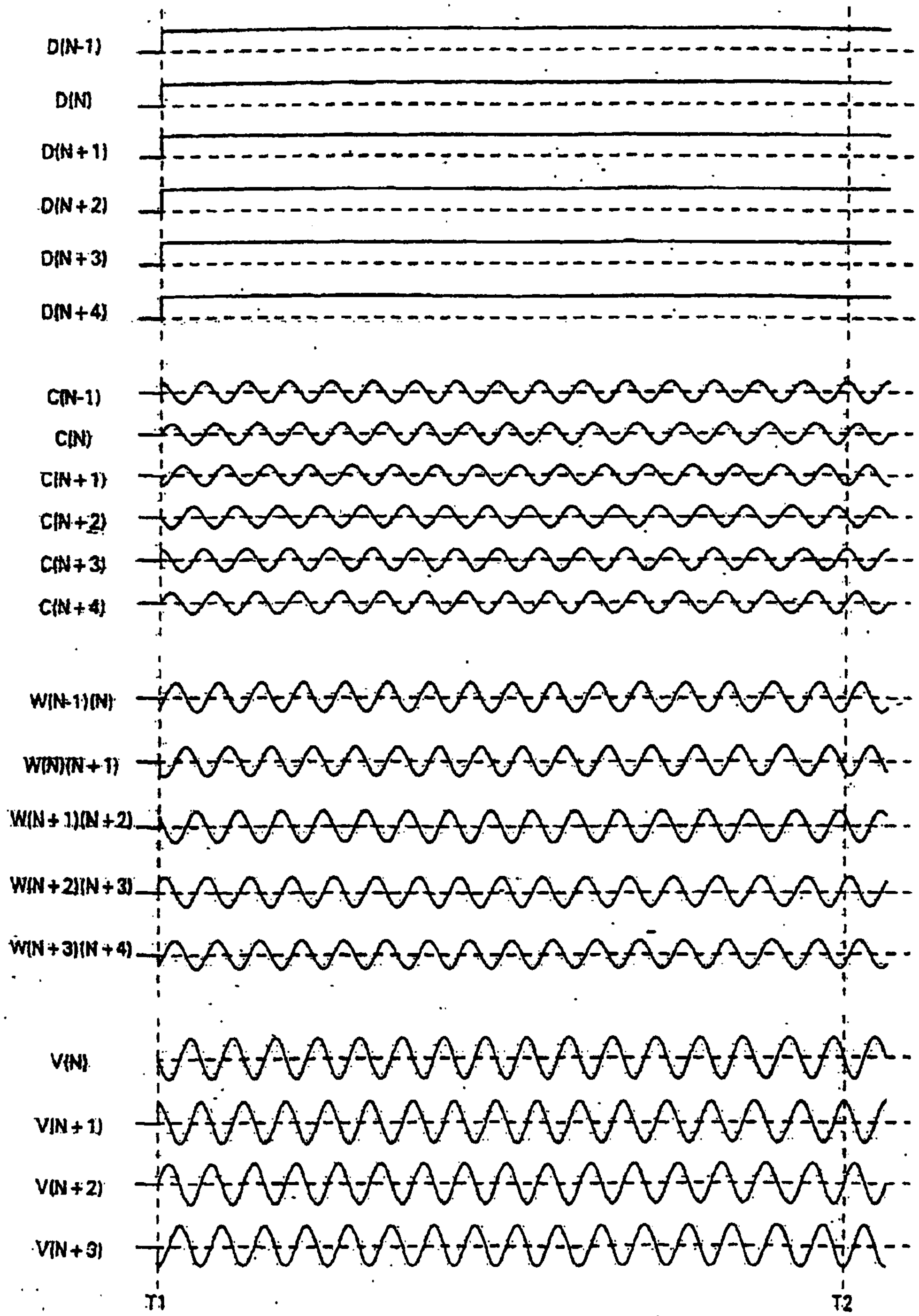



FIG. 6

FIG. 3



D(N-1)
D(N)
D(N+1)
D(N+2)
D(N+3)
D(N+4)
C(N-1)
C(N)
C(N+1)
C(N+2)
C(N+3)
C(N+4)
W(N-1)(N)
W(N)(N+1)
W(N+1)(N+2)
W(N+2)(N+3)
W(N+3)(N+4)
V(N)
V(N+1)
V(N+2)
V(N+3)
T1
T2

FIG. 4

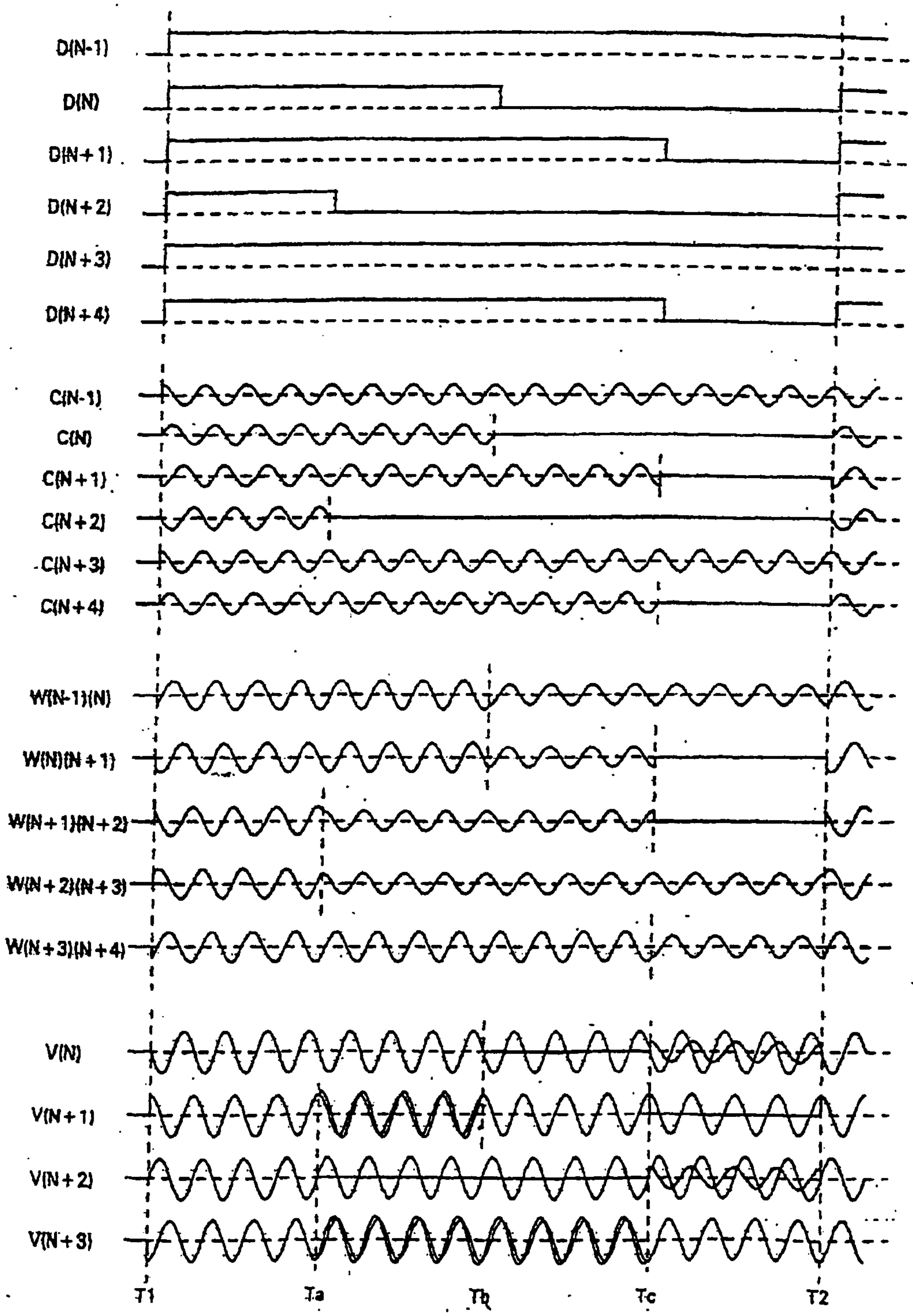
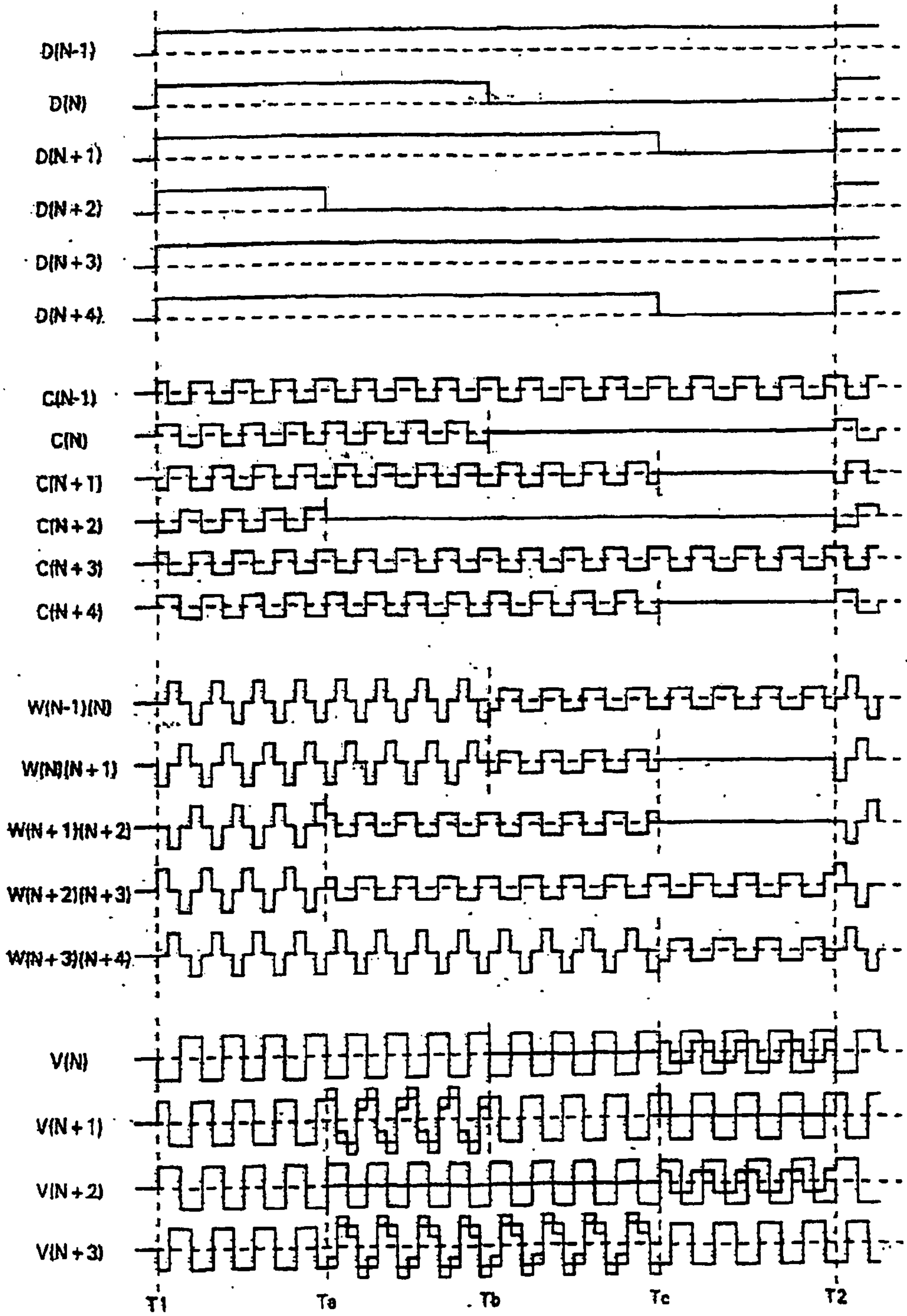

D(N-1)
D(N)
D(N+1)
D(N+2)
D(N+3)
D(N+4)
C(N-1)
C(N)
C(N+1)
C(N+2)
C(N+3)
C(N+4)
W(N-1)(N)
W(N)(N+1)
W(N+1)(N+2)
W(N+2)(N+3)
W(N+3)(N+4)
V(N)
V(N+1)
V(N+2)
V(N+3)
T1
Ta
Tb
Tc
T2

FIG. 7


D(N-1)
D(N)
D(N+1)
D(N+2)
D(N+3)
D(N+4)
C(N-1)
C(N)
C(N+1)
C(N+2)
C(N+3)
C(N+4)
W(N-1)(N)
W(N)(N+1)
W(N+1)(N+2)
W(N+2)(N+3)
W(N+3)(N+4)
V(N)
V(N+1)
V(N+2)
V(N+3)
T1
Ta
Tb
Tc
T2